MODULE FOR HEATING THE INTAKE GASES OF AN INTERNAL COMBUSTION ENGINE INCORPORATING ELECTRONIC TEMPERATURE CONTROL

DESCRIPTION

OBJECT OF THE INVENTION

This invention relates to a heating module used for heating the gases which are introduced through the intake pipe of an internal combustion engine incorporating electronic temperature control, consisting of the following fundamental parts: heating element (resistance in the form of a continuous strip), and power control circuit which measures a temperature representative of the heating module and which manages the distribution of electrical energy in the heating element.

The object of the invention is to enable the heating module to be installed in an intake manifold, preferably of plastic, without damaging the same due to excess temperature, and optimising the performance of the engine, which is achieved through measurement of one of the representative temperatures of the heating module and the insertion of the control electronics between the supply source and the heating element so that the accidental or intentional connection of said heating element to the battery is prevented.

BACKGROUND TO THE INVENTION

For heating the intake air of Diesel engines with high cubic capacities, such as those used in industrial and commercial vehicles, use is currently made of heaters such as those described in patents of invention US 4 512 322, US 4 685 437, US 5 988 146, WO 00/34643. These heaters consist of a frame of metal, such as aluminium, on which is fitted a resistance in the form a strip insulated from it by ceramic insulants, and incorporating no element which enables its temperature to be determined and a safety function to be implemented that enables us to fit said heating module on a plastic manifold without the risk of damage to the same due to excess temperature.

All the features described above could be used directly to perform the following functions without their being optimised for any of the functions:

- Helps with cold starting
- Helps with regenerating the particle filter
- Helps in reducing pollution emissions

However, none of these functions enables the heating module to be fitted in the plastic intake manifold, optimising engine performance and ensuring that damage to the said manifold will be caused by excess temperature under any circumstance.

To optimise engine performance the heating module must meet the following requirements:

- MINIMUM CHARGE LOSS
- SHORT RESPONSE TIMES
- CAPACITY TO DISSIPATE HIGH POWERS

As we shall see, the more efficiently these design conditions are met, the better the operating temperature of the resistance, and hence the greater will be the losses of heat through the frame of said resistance to its surrounding area and the more difficult it will be ensure that damage to the manifold will not be caused by excess temperature in the event of "degraded" operation.

The situation is therefore as follows. The power dissipated in the resistance is:

$$P = V^2 / R$$

where V is constant and equal to the battery voltage, so that if we want to be able to supply high powers we require a resistance with a low ohmic value.

We also know that the resistance of a flat strip of length L and cross-section S of a material of resistivity ρ is:

$$R = \rho \, . \, L / S.$$

Since the value of R is determined by the power required to be dissipated in the resistance, and ρ will be established once the material of said resistance is selected, the only parameters that can be modified to meet the design requirements are the length L of the strip and its cross-section s. On the other hand, it is well known that the smaller the exchange area the greater will be the temperature of said area for transferring the same quantity of heat to the air flow. Thus:

A) Strips of short length L must have a low S and hence a small exchange area, which will impose high operating temperatures and minimum charge loss. At the same time the response time t_{ON} will be low (t_{ON} = K . L^2 . ΔT . BAT^2 (is heated in less time).

B) For the same ohmic value, and selecting a strip of long length L and large cross-section S, the operating temperature may be lower because the exchange area will be greater, and hence the charge loss value will be high. t_{ON} is also high.

Summarising, resistances designed according to the instructions given in section A) give
us the following:

1) minimum charge loss
2) high dissipated power
3) short response times
4) relatively high operating temperature, which imposes a disadvantage (impossibility) in terms of fitting the heating module in the plastic manifold. It is pointed out that the higher temperature of the resistance the higher will be the potential for losses and the higher will be the temperature of the frame.

Moreover, designs which follow the guidelines in section B) for the same dissipated powers give us:

1) greater charge losses
2) longer response times
3) lower resistance temperatures.

This means that the heating modules designed on the basis of these guidelines, which are those deriving from the aforementioned patents, could be installed in plastic manifolds, but to the detriment of the engine performance characteristics, such as:

1) Loss of power (charge losses at the intake result in a slower air flow to the inlet of the cylinders and loss power).
2) Longer starting times (longer pre-ignition time)
3) Higher pollution emissions due to the long response times prevent sophisticated
heating strategies for the intake gases following sudden accelerations and decelerations of the engine.

All the above-mentioned previous patents disclose no safety functions based on the control and measurement of any of their parts to guarantee their optimum functionality under the conditions mentioned, and in others, which we call shall degraded operation, e.g. in those found in the repair workshops, where, in the face of possible damage, the operative could feed the power directly from the battery and measure the current to determine whether the heating module is broken or not. In this case, the more strictly the requirements for minimum charge loss, high dissipated power and short response times are adhered to, the frame will reach the maximum operating temperature of the plastic in less time and the manifold will begin to deform before the operative completes the test. A similar statement should be made with regard to a control failure, for example one resulting from an accident and the heater is connected directly to the battery, which could cause a fire in the vehicle. By inserting a control circuit between the battery and the heating element, which automatically cuts off the power supply if the temperature of the frame

exceeds the temperature for safe operation, we guarantee that in the case of degraded operation the heating module does not do any damage to the other parts of the engine.

DESCRIPTION OF THE INVENTION

The module for heating the intake gases of an internal combustion engine, incorporating electronic temperature, according to this invention, satisfactorily solves the problem outlined in each of the points previously described, comprising two fundamental parts: a heating element (resistance in the form of a continuous strip), and a power control circuit which measures a representative temperature of the heating module and manages the distribution of electricity in the heating element, which parts are located or integrated in the same frame of metal, preferably aluminium.

Within the same heating module the heating element is installed so that it is insulated from the frame by means of ceramic insulants on which it rests and expands freely to absorb their expansions, thereby preventing them from deforming. This heating element is connected electrically at one of its ends to the frame, by means of which it is earthed, and it is connected at the other end by means of a conductor to the power control circuit, from which it derives the battery supply. It should be stated that when we talk of the heating element we are referring to a modular heating element in which the electrical resistance, in the form of a continuous strip, may be a single resistance or several resistances. Whether the heating element consists of a single or several resistances will determine the maximum power required to be dissipated in each particular application (unit cubic capacity of the engine, number of cylinders, etc.), and the power that each of the power switches is able to manage so that each switch controls a single resistance.

The power control circuit adhered to (located on) the frame itself consists of at least the following components: power switches (as many as the number of resistances of the heating element, each controlling one resistance), control logic, temperature sensor / sensors and control connector by means of which communication is made to the Electronic Control Unit (ECU) of the engine. For

reasons of thermal transmission, each of these components is mounted on a base, preferably ceramic, adhered with a heat conducting adhesive or gluing material to the frame. This circuit provides preferably modulated control of the power dissipated in the heating element. The quantity of dissipated power supplied to the intake air flow is determined at all times by the ECU, and if at any time the temperature of the frame exceeds the maximum temperature of the plastic of the intake manifold, with which it is in contact, the power supply to the heating element is then automatically cut off.

Although, as mentioned above, the present heating module, incorporating a power circuit, is designed to be installed in a plastic manifold, this does not rule out the possibility of installing it in manifolds of other conventional materials, particularly those consisting or formed from materials with a low operating temperature.

A knowledge of the temperature of the frame of the heating module is essential for providing a protective function that prevents the temperature of the points of the module that are in contact with the plastic intake manifold from exceeding that at which the plastic begins to deform. There are two possible ways of determining this temperature, one by indirect methods and the other, the best method, by directly measurement, by putting a temperature sensor in direct contact, or via low, known thermal impedances, with the heating module support.

The indirect methods will depend mainly on the exact location of the temperature sensor or sensors, these being as follows:

1) Measurement of the temperature of the intake manifold at points close to the points of contact with the heating module. This method can be optimised because the thermal conductivity of the plastic is very low, and a minimum tolerance in the positioning of the sensor will be expressed in very large temperature differences. Moreover, the sensor must be installed by connecting it to the control circuit with cables that can be incorporated in its respective connector, which will increase its cost.

2) Measurement of the temperature of the heating element (of the resistance). Due to the high temperatures which can be reached in the heating element (1000 °C), there are only two ways of carrying out the measurement, one by designing the heating element so that it can be used as a thermocouple (as proposed in patent application PCT/ES02/00369 of the same applicant), which describes a resistance with an integrated thermocouple or a thermocouple welded to the heating element. However, this is an expensive solution.

3) Measurement of the increase in temperature of the air flow downstream from the heating module. The measurement of the temperature of the flow will depend on the position of the sensor, particularly if it is very close to the heating module. Because it is an obstacle to the passage of air, it produces local turbulences which prevent the measurement from being totally accurate. If the measurement is carried out further away from the heating module, this will make installation more expensive because it may incorporate a connector, it may have a specific housing in the manifold, etc.

The preferred assembly is one which enables the temperature sensor to be incorporated in the control circuit, and where the circuit is in turn incorporated in the frame, which allows direct measurement of the temperature of the said frame. This assembly, as well as the location of the sensor, will prevent direct connection of the heating element to the battery, which will enable us to install it safely in the plastic manifold because the heating element can only be supplied via the control circuit, which will require the temperature sensor to be located at the measurement and operating point.

This assembly solution provides a number of clearly advantageous characteristics of the heating module, which are described below.

- It facilitates the measurement of the temperature of the frame of the heating module and protects it from overheating, at minimum cost, because this is a single module which integrates all the measuring and actuating elements.

- The module provides a robust temperature measurement because there are no cables or connections.
- During manufacture the position of the temperature sensor on the frame itself means that the protective temperature has a low dispersion.
- Due to its compactness, the mechanical strength is very high and the module satisfactorily supports the typical vibrations of an internal combustion engine.

DESCRIPTION OF THE DRAWINGS

To supplement the description that has been given, and to assist in providing a clearer understanding of the characteristics of the invention, in accordance with a preferred embodiment of the same, a set of drawings is attached as an integral part of the said description, in which the following is shown by way of non-exhaust illustration:

Figure 1. – Shows a front view of the module for heating the intake gases of an internal combustion engine, in which its constituent elements are shown.

Figure 2. – Shows a representation of the heating element, consisting of one or more resistances of the strip type.

Figure 3. – Shows a perspective view of the control circuit in which can be seen the power switches, the control logic and the integrated temperature sensor.

Figure 4. – Shows a schematic diagram indicating the connections of the heating module to the electronic control unit and the battery.

Figure 5. – Shows the heating module incorporated in a manifold, indicating the temperature sensor inserted in the wall of the plastic manifold.

Figure 6. – Shows the heating module incorporated in the manifold, indicating the temperature sensor of the thermocouple type forming part of the heating element.

Figure 7. – Shows the heating module incorporated in a manifold, indicating the temperature sensor downstream from the heating module.

Figure 8. – Shows the heating module incorporated in a manifold, indicating the temperature sensor integrated in the control circuit.

PREFERRED EMBODIMENT OF THE INVENTION

The module for heating the intake gases of an internal combustion engine, which constitutes the object of this invention, is of the type used for heating the gases circulating through the intake pipe (13) by means of a heating element (1) supplied by a battery, which receives its supply from a power control circuit (4) controlled by an electronic control unit (ECU) (12) of the engine.

The heating module is characterised by this basic configuration in that it incorporates a metal frame(2), preferably of aluminium, in which is adhered the power control circuit (4), and in which is installed heating element(1), both forming the same module to allow electronic control of the temperature of the intake gases.

The power control circuit (4) is preferably mounted on a ceramic base (10) adhered with a heating conducting product to frame (2), and incorporates essentially a control logic (8) to which is connected a temperature sensor (3) and at least one power switch (6), which controls heating element (1), consisting of one or more resistances, preferably a power switch(6), for each resistance.

From power control circuit (4) runs a supply connection (9), which is led to the positive terminal of the battery, an electrical connection, cable or soldered terminal (5) integrated in the module, which is tamper-proof or supplied from the outside, which connects the circuit to the heating element (11), which is in turn connected to the earth of frame (2) at its other end, and a control connector (7)

which transits the temperature signals picked up by temperature sensor (3) to the electronic control unit of the engine, which responds by transmitting signals to control circuit (4) to regulate the power applied to heating element (1).

Heating elements (1) consist of resistances of the strip type, which are mounted on ceramic insulants (1), in which the resistances are supported and expand in order to absorb expansions and prevent their deformations, the ceramic insulant (11) consisting of an independent element for each resistance, or forming a single monobloc part which incorporates all the resistances.

The module for heating intake gases can be used essentially for intake manifolds (14) consisting of materials with a low operating temperature, particularly plastic manifolds.

A preferred embodiment is considered in which temperature sensor (3) is integrated in control circuit (4) to provide precise control of the temperature, as shown in Figure 8.

In other alternative designs, other assembly solutions for temperature sensor (3) are considered. Temperature sensor (3) may be inserted in the wall of plastic manifold (14), as shown in Figure 5, can be integrated in heating element(1) itself, as shown in Figure 6, or can be arranged downstream from heating element (1), a shown in Figure 7.

For connecting temperature sensor (3) to control circuit (4), shown in Figures 5, 6 and 7, use will be made of a cable (15), with the optional insertion of an additional connector (16).